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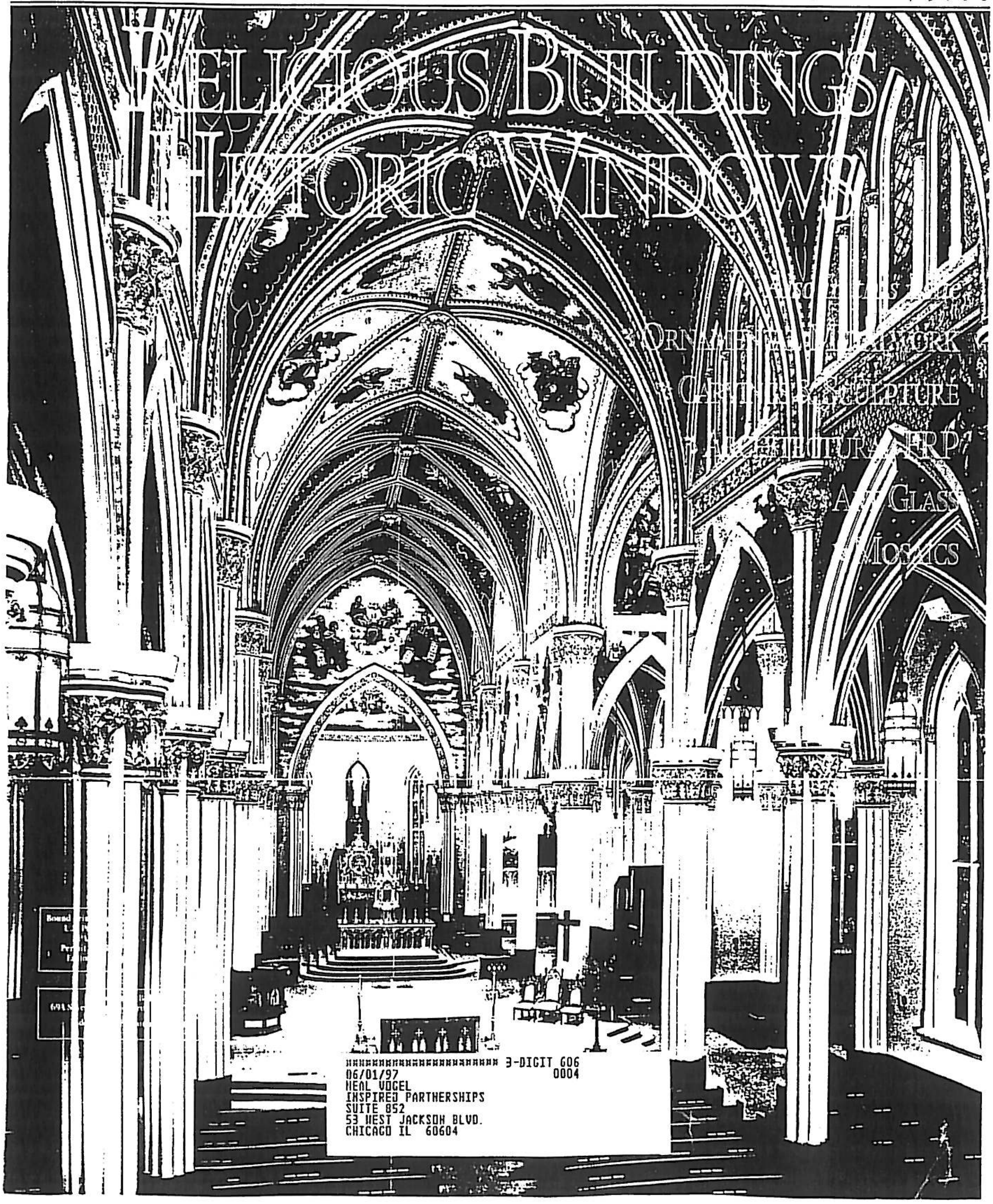

Windows in Religious Buildings:
HIGHER STANDARDS NEEDED FOR PROTECTIVE GLAZING

Installation of protective glazing is very popular on religious buildings for storm protection and security. However, a recent study shows that improperly designed secondary glazing can cause more problems than it cures.

BY NEAL VOGEL, *Inspired Partnerships, Chicago, Ill.*
The vast majority of U.S. churches have protective glazing (PG) today, yet a recent study proves that it causes serious damage to stained-glass windows nationwide by increasing condensation and heat build-up in the airspace, and preventing routine maintenance. As part of an initial investigation of protective glazing issues, Inspired Partnerships performed a field survey of 100 PG installations nationwide. Condensation was found in 70% of the windows. Nearly all plastic glazing (over 60%) had clouded over, while some of the windows were too obscured to see through at all. Only 4% of the PG installations were intentionally vented while another 19% self-vented due to deteriorated sealants or broken glazing. Despite recorded heat and condensation problems, most of the stained and painted glass was in good condition overall, but the leading, bracing, and window frames were severely deteriorating in many windows. PG also prevents routine window maintenance. Approximately one-third of the windows surveyed required maintenance to the frames that were no longer accessible due to fixed storm glazing. For historic churches and synagogues, plastics (acrylics and polycarbonates) in particular have become the vinyl siding problem of windows. The Protective Glazing Study calls for higher standards in the glazing industry to address the current problems with PG materials and installations, and to employ PG only when necessary.

Promotion and Use of Protective Glazing

The ever-changing face of religion, architecture, art, and the economy since the 1950s has resulted in greater competition for fewer stained-glass installations. In order to stay in business, many contractors fully endorse PG, which is a lucrative aspect of the glazing industry. Brochures collected since the 1960s reveal that most contractors use at least some of the following reasons to promote PG to consumers: vandalism, security, energy, comfort, conservation, weather, sound, and maintenance. Civil unrest during the 1960s motivated a number of congregations to cover their stained-glass windows with PG for vandalism protection. Fear over vandalism and theft, whether justified or not, remains a powerful motivator for PG, especially in the inner-cities.

The 1973 energy crisis further convinced many misinformed churches that secondary glazing was a worthwhile investment to reduce fuel bills. Today, energy savings remains among the three most popular ways to promote protective glazing, along with vandalism and storm protection. However, testing for the study demonstrates that the perceived energy value is a myth for intermittently occupied buildings (e.g. churches, synagogues). The results show that the energy savings from properly vented protective glazing has a very slow payback of more than four decades in the continental U.S. and does not warrant the expense of installation.

Perhaps more important than fear of vandalism or energy concerns is the financial inability of many congregations to fund stained-glass restoration. Many dwindling congregations faced with the reality of restoration costs choose to defer the expense by burying their window problems temporarily with PG. Regardless of the aesthetic or conservation impact on stained glass, PG stops leaks and drafts through deteriorated windows and postpones the inevitable restoration costs. Procrastination has been the decision of thousands of congregations nationwide, and today about 80% of U.S. churches with stained glass have some type of PG. But in recent years, a stronger sense of stewardship, intensified professional criticism of PG, and a swelling restoration market is prompting the question, "Do we need protective glazing...or do we really need restoration?" *(For a discussion of stained glass restoration, see the article on p. 56. — Ed.)*

Aesthetics

Although the glazing industry has claimed many advantages for PG, no one has claimed that it improves aesthetics. Windows that are not covered with PG look the best [Figs. 1 & 2]. The design, materials, and installation of secondary glazing can have a serious aesthetic impact on stained-glass windows and historic buildings. The exterior appearance of stained glass is often as important as its interior appearance — particularly in ecclesiastical architecture. Virtually all Gothic style churches rely on pointed-arched window frames and delicate window tracery to accentuate the vertical design. When a conventional grid is installed over the original frame, the building's architectural character is severely compromised [Fig. 3].

Most glass products today are very stable and will retain excellent clarity over the years. However, it is important to consider how light will play off the glass surface; reflections are disconcerting when PG is viewed on an angle. Some PG systems employ leading to break up the broad expanse of sheeting and mitigate the glare. On primary facades, and where leading and texture are of great importance to the perception of the building, this is a worthwhile approach. Plastics are also susceptible to glare, but worse, they become cloudy (nearly opaque) over time. Manufacturers recognize this chronic problem and do not warrant their products beyond a few years. Aesthetically, all plastic products are a poor investment and their initial appearance will certainly decline in a relatively short period of time.

The design of the PG framework should be compatible with the design, materials, and color of the original stained-glass window frame. Installations in which the glazing is cut to fit within the existing tracery are visually most successful. An advantage of wood and steel frames is that they can be painted to match or complement the original frame. Select materials carefully to enhance the windows and architecture.

Maintenance

The most common result of an improper PG installation is condensation. Owners of religious buildings are notorious for neglecting maintenance, particularly on high windows; paints and sealants nearly always fail before they are renewed, causing leaks into (often) unvented PG. Moisture, which promotes glass corrosion, gets trapped between the glazing, and condenses on the stained glass, PG, framing members, and window surround.

Protective glazing is often promoted to alleviate window maintenance. Unfortunately, it is typically installed in a fixed position, becoming a *barrier* to window maintenance. If sealant integrity is maintained on a newly restored window, condensation may not occur for a while. Soon, however, weathering deteriorates paints and sealants, and excessive moisture inevitably occurs. Moreover, PG imparts a false sense of security so routine window maintenance is often overlooked as a property management responsibility. Even if failing paint and deteriorating wood are apparent, building owners are reluctant to remove PG due to the significant cost.

Frame problems concealed behind cloudy secondary glazing are "out of sight, out of mind" and neglected. Wood windows are particularly at risk as laminations and joinery readily admit water once the paint and sealants fail [Fig 4]. Iron frames rust more quickly under humid conditions, which can deform glass and crack masonry; severe rusting can necessitate entire frame replacement. While stone tracery is generally more tolerant of improperly installed PG, damage often occurs from inappropriate sealants and anchors. Frequently, PG is mounted against masonry with fasteners that rust — staining and spalling the masonry. Unvented protective glazing also has a "greenhouse effect" on the airspace between the stained glass and secondary glazing. In the U.S., this effect occurs on unshaded east, west and south elevations. An unvented airspace can be subjected to high temperatures, measured up to 165°F, as solar radiation is absorbed throughout the day. Perhaps more critical than temperature peaks are the exaggerated temperature fluctuations in an unvented PG airspace; one unvented PG airspace swung 90°F over a 24-hour period!

These exaggerated temperature swings augment the expansion and contraction cycle of the lead came holding the glass together. Lead has a high coefficient of thermal expansion and a low modulus of elasticity. The expansion-contraction of lead came from thermal change is approximately three times that of steel, four times glass, and seven times wood (typical adjacent materials). As it heats up, lead came expands along its length, but it does not rebound when it cools. The pressure generated by this continuous expansion causes stained glass to buckle and bow out of plane. Research indicates that if a leaded-glass panel is going to deform, it will deform more rapidly when exposed to higher temperatures; deformation occurs twice as fast at 120°F than at 70°F.

Many American windows are having deformation problems that seem related to heat build-up in unvented PG installations. Although imported, plated, and high-end windows show few signs of heat-related deterioration, low-end art glass or "catalog" windows (particularly those fabricated with narrow 1/8" came) appear to be more seriously affected by heat build-up. New, or recently re-leaded windows installed with unvented PG are at the greatest risk. These supertight installations produce the highest temperatures. Therefore, deformation is accelerated on the front end of the window's life, which is the least desirable effect. The service life of a stained-glass window, at least one that is susceptible to deformation, can be reduced by years due to unvented PG.

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***Protective glazing (PG)** is defined here as a secondary layer of glass or plastic on the exterior of a stained glass window; it is also described as storm, double, outer and secondary glazing throughout this article. **Stained glass** pertains to all types of leaded glass.*

PROTECTIVE GLAZING, continued from page 80

Unfortunately, this process occurs over many years and is difficult to document under actual weathering conditions.

Secondary glazing frequently prevents normal window operation as well. Almost all churches require some ventilation during various seasons, and permanently mounted secondary glazing often immobilizes ventilators. Sometimes building owners look to more expensive alternatives, such as central air conditioning, to solve ventilation and comfort problems.

Light & Sound Transmission

All secondary glazing reduces natural light through stained glass. For most types of glass, the light reduction is insignificant. Clear, clean, polished glass reduces light transmission only 3%, while clear, clean Lexan reduces light transmission about 16%. However, when dirt collects on the inside surface of the PG, and when plastics become cloudy, light can be dramatically reduced. Removing or replacing old PG with clean glass can increase light transmission over 100%. All secondary glazing, whether plastic or glass, reduces sound transmission through stained glass. This can be beneficial when excessive urban or industrial noise is present. Laminated glass, particularly laminated insulating glass, is the best choice in reducing sound transmission. True sound reduction also varies depending upon the depth of the airspace — the deeper, the better. Under normal circumstances, though, the sound transmission is only reduced a negligible 5-15% with protective glazing.

Installation Guidelines for Protective Glazing

It is better *not* to apply protective glazing than to apply it improperly. However, there are instances where recurrent vandalism, stained-glass conditions, or stained-glass value warrants a protective glazing system. Conservation of the stained glass itself should be the overriding consideration for any PG installation. Isothermal protective glazing, where the stained glass is remounted on the inside of insulated glass and the airspace is vented, is the best method in many instances for stained-glass conservation. Isothermal glazing guarantees that no condensation will occur on the interior surface of the stained glass, which is a primary concern when unstable paint conditions are apparent. However, isothermal systems are expensive, require careful design, and are not necessary for most stained-glass windows in America. When designing PG installation details, the following issues must be considered:

1. *Framework Configuration:* Successful PG installations mimic the shape of the tracery or mullions that support the stained glass.

2. *Texture, Leading & Frame Color:* For buildings where the glass texture, leading pattern, or exterior color (opalescent glass) are important to the architectural design, large sheets of PG are an unacceptable compromise.

3. *Depth of Window Opening:* Installations that maintain a reasonable setback and engage window moldings and tracery, rather than covering them, look better.

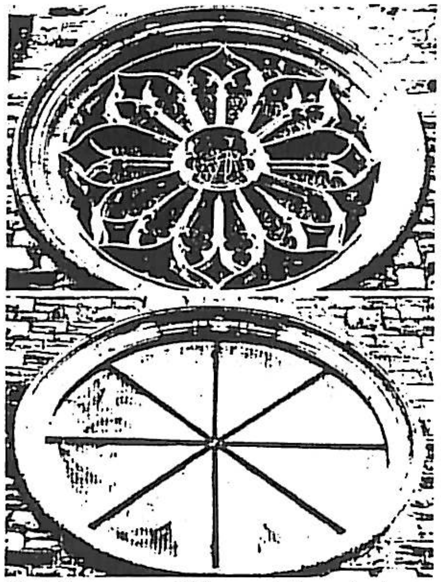
4. *Glazing Attachment Method:* PG should never be attached directly to the existing frame, but rather attached and securely anchored within the frame surrounding the stained glass. Glazing should be placed within sashes or reglets to allow for expansion/contraction, and all fasteners should be nonferrous.

5. *Frame Material:* Frame components should be fabricated of the same material (either metal or wood) as the original window surround. Bronze or anodized aluminum may be acceptable, but mild steel will rust and should not be used. In coastal areas, special coatings or alloys may be required to avoid corrosion.

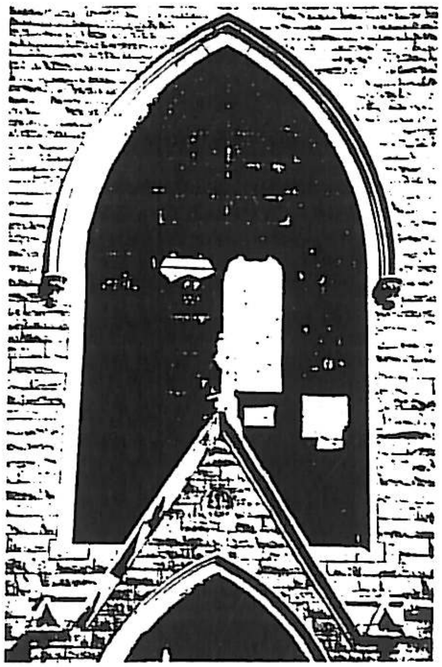
6. *Glazing Material:* Laminated glass is recommended in most instances due to its durability, resistance to breakage, and stable clarity.

7. *Venting:* The airspace formed by protective glazing must always be vented.

There are three primary reasons for venting PG: (1) to allow condensation to evaporate; (2) to equalize the pressure in the airspace with the atmosphere; and (3) to minimize the temperature variation in the airspace. Where and how the glazing is vented depends on the type of installation and



The delicate tracery of this rose window, a dominant exterior architectural feature, was totally obliterated by this insensitive protective glazing.



The grid of protective glazing applied over this lancet window prevented vandalism, but also destroyed the character of the window.

The decay visible in the wood tracery and window frame reveals an extreme case of the type of damage that can be caused by improperly installed secondary glazing.

the climate. In a northern temperate climate, the airspace should generally be vented to the exterior of the building. In a hot, humid climate, venting to the interior should be considered if the building is air-conditioned throughout most of the year. The venting needs of particular windows may vary greatly. The amount of venting required is dependent on the micro-environment that the window is subject to based on climate, orientation, and the depth of the airspace.

If applied frames are used to support the PG, holes can be drilled through the frame to allow for air movement. The holes must be at the top and bottom of the window and be designed to keep out rain and insects. If plastic glazing is used, the holes can be drilled through the plastic in similar fashion. If the exterior glazing is leaded, vents (stainless steel screens) can be glazed into the window during fabrication. If glass is used, the corners can be cut off and fitted with a hooded vent screen comprised of glass, stainless steel screening, and lead came. The openings should only occur at the top and bottom to cause upward airflow through the airspace (i.e. "chimney effect").

Exact specifications as to the amount of venting do not yet exist, but it is clear that the best system is one that can be easily modified to allow for greater or lesser airflow. In-situ experimentation remains the best way to determine proper venting. PG installations should be monitored throughout the year for evidence of condensation, such as moisture trails (faint streaks from drips) on the interior surface of the stained glass or PG.

Wire screens are often a good alternative to glazing materials and are gaining favor, particularly in Europe. They are an effective, and often inexpensive, impediment to vandalism and impact damage to stained-glass windows. They also provide some security and allow for periodic rinsing of the windows on the exterior. When designing screens, consider the material of the screen, the size of the wire and the mesh, and the method of attachment to the building. The least expensive material is galvanized wire, but it is inadvisable for use in churches due to the high maintenance required to prevent rusting. Copper or bronze may also be used to fabricate screens, but they cost more than galvanized. If left unpainted, copper can stain the building, particularly light-colored stones. Stainless steel has the greatest longevity combined with the least maintenance, but is also the most expensive. Whichever material is used, it should be painted, patinated, stained, or otherwise darkened. The screens will then visually disappear to enhance the appearance of the stained glass and building from the exterior.

All stained-glass windows and their frames need routine maintenance to ensure a long service life. The PG should be designed to allow for periodic maintenance to the frames. Applied frames used to support the PG should cover as little of the original frame as possible. It is a misconception that covering the entire existing frame with PG will obviate the need for routine maintenance. The effects of ultraviolet radiation, heat, and moisture are rarely negated by PG, and are often worsened. When installed incorrectly, "protective" glazing becomes "destructive" glazing.

Most windows in the U.S. do not have to be protected from anything other than vandalism. The most stable, albeit most expensive, protective glazing system is an isothermal one. Screens, or laminated glass vented externally, provide excellent cost-effective protection against vandals when such protection is truly necessary. Aesthetically, all leaded glass looks best uncovered as originally designed; the challenge to the architect, client, or contractor is to devise other ways to improve security and minimize vandalism around the property (fencing, landscaping, lighting, etc.). The goal of the Protective Glazing Study is to raise the standards for protective glazing when it must be installed. As in all endeavors, the careful consideration of all existing conditions and options will result in the most successful solution.

For Further Details

This article is based on a 1994-1996 protective glazing research project by Inspired Partnerships, based in Chicago, for The National Center for Preservation Technology and Training. It is the first study of its kind undertaken in the U.S. The entire "Protective Glazing Study" is available from: *The National Center for Preservation Technology & Training, P.O. Box 5682, Nachitoches, LA 71497 (318)-357-6410.* ■

Neal Vogel has worked extensively in stained-glass preservation while working for the New York Landmarks Conservancy and as the Director of Technical Services for Inspired Partnerships, in Chicago, for the past eight years. He has surveyed over 280 historic stained-glass installations, has consulted on dozens of stained-glass restoration projects, and has authored many technical articles on stained glass.